# Effect of shading treatment on stomatal behavior of *Adenophora lobophylla* at different ages

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**Abstract:** The stomatal behavior of *Adenophora lobophylla* of different age structures was studied in July 1995 in greenhouse of the Harbin Forest Farm of Northeast Forestry University by means of shading experiment. The effects of different shading treatments on the stomatal physiological character and ecological adaptation of *A. lobophylla* of different ages were compared. The results showed that the morphological characters of annual *A. lobophylla* were more obvious than that of the perennial, but the stomatal density of annual was less than that of perennial. Growth of annual *A. lobophylla* was more sensitive to the change of environment than that of the perennial. The ecological adaptation of annual was weak, which was one of the main causes of endangered population.

**Key words:** *Adenophora lobophylla*; Age structure; Shading treatment; Stomatal behavior
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## Introduction

The growth and multiplication of plant individuals depend on various physiological functions. The primary physiological functions are photosynthesis, respiration and transpiration of plant, but they are dominated by stomatal behavior. Stomatal behavior is a complex physiological action; meanwhile it is influenced by a great deal of internal and external factors. For the endangered plant species *Adenophora lobophylla*, internal mechanism of endangered population is disclosed. A lot of studies have now been done on several aspects such as geography distribution, living environment, life growth, reproduction ecology, and pollination biology from the view of populations ecology (Zhang 1998; Zhang 1998; Zu 1997; Guo 1997), but the studies on stomatal physiological characteristic of *A. lobophylla* have not been reported. According to the measure analysis of net photosynthesis rate, preliminary studies of stomatal characteristic of *A. lobophylla* of different ages were conducted under shading experiments in this paper and physiological diversity was analyzed further, which provide scientific basis for working out a rational protection measures.

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## Material and method

All experiments were processed in greenhouse of the Harbin Forest Farm of Northeast Forestry University. *A. lobophylla* was planted in big pot that the diameter was 33 cm, and the height was 25 cm. The seeds of *A. lobophylla* were gathered in Jinchuan County (31°08'-31°58' N, 101°13'-102°19' E) in Sichuan Province. *A. lobophylla* were artificial cultivated annual or perennial seedlings.

All shading treatments were carried out in July. Experiment field was divided into five shading areas, each area was made up of four pots, and covering was white gauze of different layers. Shading rate of each shading area was 20% (photosynthetically active radiation about 782.32 $\mu mol \cdot m^{-2} \cdot s^{-1}$), 40% (photosynthetically active radiation about 586.74 $\mu mol \cdot m^{-2} \cdot s^{-1}$), 60% (photosynthetically active radiation about 391.16 $\mu mol \cdot m^{-2} \cdot s^{-1}$) and 82% (photosynthetically active radiation about 176.022 $\mu mol \cdot m^{-2} \cdot s^{-1}$). The unshaded area (photosynthetically active radiation about 977.90 $\mu mol \cdot m^{-2} \cdot s^{-1}$) was as control area. *A. lobophylla* ecological adaptation of annual or perennial in each shading area was analyzed by comparison analysis.

All measurements were carried out during 9:30-11:30 at fine days in August. At each shading area, normal individuals of annual or perennial were chosen. Three fully expanding leaves in the middle position of each individual were selected for measurement with LI-6400 Portable Photosynthesis System. Every measurement was repeated two times; therefore, every mean parameter was calculated

from six measurements. Net photosynthesis rate (Pn), transpiration rate (Tr), intercellular $CO_2$ concentration, stomatal conductance (Gs), as well as environment factors were measured. At the same time, sample leaves of identical position were fixed by 3% glutaraldehyde solution so that the characteristics of stomatal behavior, stomatal density and stomatal open were observed. Then all the figures were measured and processed in laboratory. The characteristics of leaf stomatal shape were observed by electric scan microscopy. The stomatal relative parameter was obtained by computer vision system.

## Results and discussion

Photosynthesis of green plant was affected by various interior and exterior factors. Main exterior factors were light intensity, $CO_2$ concentration, temperature and water, and so on. Interior factors was affected by exterior factors in many conditions, especially stomatal behavior was one of main susceptible factors (Guo 1997; Sheng 1996; Yang 1997; Yan 1998). Table 1 showed the main environment factors in different shading areas. With shading intensity increasing, air temperature and light intensity decreased. Air relative humidity and leaf surface $CO_2$ deficit increased, but leaf temperature and air $CO_2$ concentration had not changed obviously. The results demonstrated that transpiration rate and intercellular $CO_2$ concentration of *A. lobophylla* of annual and perennial had changed under different shading intensities (Fig.1, Fig.2). Transpiration rate and intercellular $CO_2$ concentration of perennial *A. lobophylla* at 20% shading intensity were higher than those at 40% shading intensity.

Transpiration rate and intercellular $CO_2$ concentration of the perennial with 60% & 82% shading intensity increased gradually and maintained at a stable level. Transpiration rate and intercellular $CO_2$ concentration of annual *A. lobophylla* decreased with shading intensity increasing.

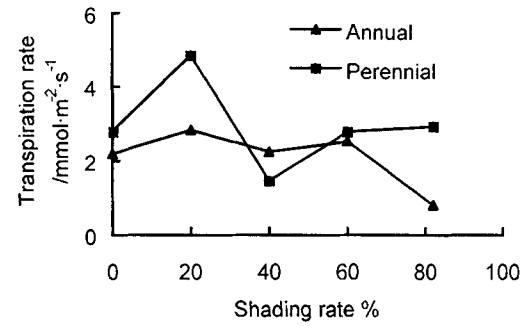


**Fig. 1 Transpiration rate of annual and perennial *A. lobophylla* in different shading levels**

This indicated that transpiration rate and intercellular $CO_2$ concentration of annual *A. lobophylla* were affected greatly by shading intensity increasing, and 20% shading intensity was fitter for the growth of perennial.

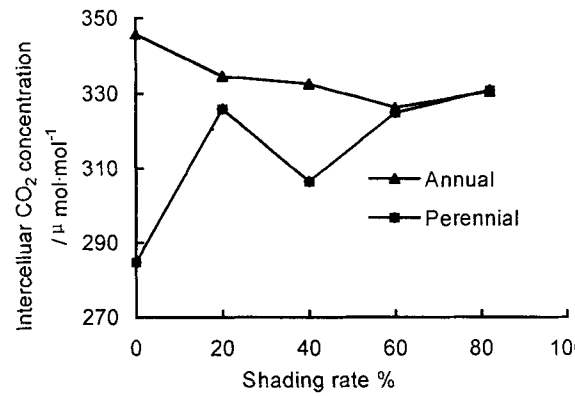


**Fig. 2 Intercellular $CO_2$ of annual and perennial *A. lobophylla* in different shading levels**

**Table 1. Relative environment factors under different shading treatments**

| Shading rate % | Air temperature /°C | Leaf temperature /°C | Leaf surface $CO_2$ deficit /μmol·mol$^{-1}$ | Air $CO_2$ concentration /μmol· mol$^{-1}$ | Light intensity /μmol·m$^{-2}$·s$^{-1}$ | Relative humidity % |
|---|---|---|---|---|---|---|
| 0 | 30.342±0.004 | 27.968±0.042 | 1.59±0.113 | 355.86±0.233 | 977.9±9.631 | 23.042±0.057 |
| 20 | 29.87±0.036 | 28.832±0.050 | 1.773±0.031 | 354.6±1.241 | 782.32±7.705 | 23.98±0.936 |
| 40 | 28.708±0.056 | 27.036±0.022 | 1.752±0.012 | 353.48±0.075 | 586.74±5.779 | 27.27±0.274 |
| 60 | 28.612±0.004 | 27.635±0.047 | 2.190±0.010 | 354.58±0.107 | 391.16±3.852 | 25.308±0.062 |
| 82 | 28.106±0.036 | 27.616±0.035 | 2.611±0.010 | 354.37±0.280 | 176.022±1.734 | 26.191±0.352 |

The analysis above showed that perennial *A. lobophylla* have an adaptability to shading environment. The transpiration rate, intercellular $CO_2$ concentration, photosynthesis rate and stomatal conductance, as the beginning of shading treatment, were fluctuated up and down. Eventually, the trend was towards to stability. Transpiration rate, photosynthesis rate and stomatal conductance of annual in 20% shading treatment were higher than those of control area. From 20% to 82% shading rate (Fig. 3, 4), photosynthesis rate and stomatal conductance of annual *A. lobophylla* were decreased with shading intensity increasing. Transpiration rate, photosynthesis rate and stomatal conductance of annual were the lowest

geous to annual *A. lobophylla*.

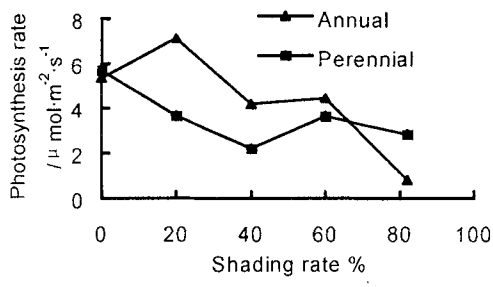


**Fig. 3 Photosynthesis rate of annual and perennial *A. lobophylla* in different shading levels**

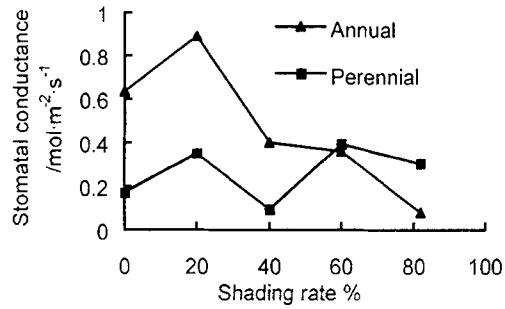


**Fig. 4 Stomatal conductance of annual and perennial *A. lobophylla* in difference shading level**

Fig.3 and Fig.4 showed the change of photosynthesis rate and stomatal conductance of *A. lobophylla* of annual or perennial under different shading treatments. With shading intensity increasing, the photosynthesis rate and stomatal conductance of perennial had a little change except a sharply droping at 40% shading intensity. Photosynthesis rate and stomatal conductance of annual *A. lobophylla* were highest merely at 20% shading intensity and decreased speedily with shading intensity increasing. This result indicates that the photosynthesis rate and stomatal conductance of annual *A. lobophylla* were restrained by low light.

## Conclusions

$CO_2$ and $H_2O$ are two kinds of main materials of photosynthesis. Water is indispensable in transpiration, as terraneous plant processes photosynthesis to assimilate $CO_2$. Simultaneity stomata are important channel for transforming $H_2O$ into $CO_2$ and $O_2$ between plant and atmosphere. Open and close of stomata influenced the exchange between $H_2O$ and $CO_2$, and the plant growth and biology output.

Therefore, stomata affected clearly life activity of plant individual. This indicated that leaf stomatal physiology characteristics of annual *A. lobophylla* were affected obviously by shading treatment. Stomtal conductance and photosynthesis rate of annual plant were highest only at 20% shading intensity, and others parameters of annual dropped down sharply with shading intensity increasing, the lowest value was at 82% shading intensity. Because of stomatal conductance decreasing, $CO_2$ and $H_2O$ through stomata were restricted, which lead to changing in transpiration rate, intercellular $CO_2$ concentration and photosynthesis rate. This result affected the biological accumulation.

Perennial *A. lobophylla* has higher ability to endure shading than the annual one and grows better under 60% and 82% shading conditions than under 20% and 40%. Only in 40% shading treatment, the growth of perennial plant was restricted significantly. Above studies showed that perennial *A. lobophylla* has stronger adaptive ability than that of annual one. *A. lobophylla* was an endangered plant on concomitant position in natural distribution. The bulk of individuals grow in shady and damp habitat. So, in this kind of habitat, the growth and biological output of annual *A. lobophylla* were affected by its physiological characteristics. The nutrition growth of seedlings was restricted and the vital force was weaker, which was one of main causes of endangered population.

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